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ORDERED POLYMERS RESEARCH REVIEW

STATUS OF THE U.S. AIR FORCE
ORDERED POLYMERS RESEARCH PROGRAM

11-13 June 1979
Bergamo Center
Dayton, Ohio

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FINAL TECHNICAL REPORT
Contract No. F49620-79-C-0097

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ABSTRACT

This report presents a general overview of the "Ordered Polymer Research Review" organized by the University of Dayton Research Institute (UDRI) under Contract No. F49620-79-C-0097. The review was held 11-13 June 1979 at Bergamo Center, Dayton, Ohio with Dr. Donald R. Wiff (UDRI) and Dr. Thaddeus E. Helminiak (Air Force Materials Laboratory) as co-chairmen. The proceedings are included under the major headings Agenda, Abstracts, and List of Attendees. This research review was sponsored by the Air Force Office of Scientific Research (AFOSR) with Dr. Donald R. Ulrich as Program Manager.

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SECTION 1

INTRODUCTION

The research review on "Ordered Polymers" was held to provide an informal atmosphere for the participants to exchange scientific information and review progress in this Air Force basic research area.

The emphasis for this meeting was on informal discussions. The meeting was to be operated "Gordon conference" style. This also related to the quoting of data, etc. Therefore, the abstracts presented herein were written so as to convey the spirit of the presentations, not the numerical data.

Participation was mandatory for all Air Force laboratory scientists and contractors and AFOSR grantees. Outside participation by the scientific community was welcomed. Special invitation was extended to three scientists (Dr. Paul Lindenmeyer, Materials Research Consultant, Seattle, Washington; Dr. Chou-Ping Wong, General Tire Company, Akron, Ohio; and Dr. Glenn Crosby, Washington State University, Pullman, Washington).

Because of the diversity of expertise involved in this investigation, it was essential that all efforts be reviewed collectively. After such an exchange of scientific knowledge, future directions were defined in light of Air Force goals and reasonable scientific probability of achievement.

SECTION 2

AGENDA

Monday (11 June 1979)

5:00 PM DINNER
7:00 AFOSR/AFML Welcome, Comments, & Overview
8:15 SOCIAL PERIOD

Tuesday (12 June 1979)

7:00 AM BREAKFAST & REGISTRATION
8:00 Carnegie-Mellon University
10:00 COFFEE BREAK
10:30 Celanese Research Corporation
11:15 University of Massachusetts
12:30 PM LUNCH
1:30 University of Massachusetts
3:15 COFFEE BREAK
3:45 University of Dayton/University of Dayton Research
Institute
4:30 SRI International
5:15 Polymer Branch, AFML
6:30 DINNER
8:00 SOCIAL PERIOD (with informal discussion)

Wednesday (13 June 1979)

7:00 AM BREAKFAST
8:00 University of Cincinnati
8:45 Stanford University
9:30 Texas A&M University
10:00 COFFEE BREAK
10:30 Composites Branch, AFML/University of Dayton
Research Institute
11:15 Ad Hoc Planning & Coordinating Discussion Groups
(Processing/Berry; Synthesis/Arnold; Characteri-
zation/Thomas)

Wednesday (13 June 1979)

12:30 PM	LUNCH
1:30	Ad Hoc Meetings (continued)
2:30	Reports of Planning & Coordinating Group Discussions
3:15	COFFEE BREAK
3:45	Summation and Plans
5:00	ADJOURNMENT

SECTION 3
ABSTRACTS OF PROCEEDINGS

3.1 CARNEGIE-MELLON UNIVERSITY
(Dr. G. Berry, Principal Investigator)

The properties of rodlike molecules with no bulky side chains, PBO and PBT; a series of rodlike molecules with phenyl substituents, PP_m BO; and some heterocyclic chains containing ether linkages in the backbone, P(PO-CO-BO) were presented. These properties included light scattering and viscometry on dilute solutions, phase equilibria on moderately concentrated solutions, and cryoscopy on dilute solutions of some of the polymers and model compounds of their repeating units.

3.2 CELANESE RESEARCH CORPORATION
(Dr. Sang Kim, Principal Investigator)

Processing parameters and cursory mechanical properties of PBT fibers were discussed. The preparatory studies required for future processing of PBT polymers in film form were presented for constructive scientific discussion. Cooperative interaction with solution property and morphology study contractors was indicated.

3.3 UNIVERSITY OF MASSACHUSETTS
(Dr. E. Thomas, Dr. R. Stein, and Dr. F. E. Karasz,
Principal Investigators)

Detailed morphology study of findings for selected areas in fibers were presented. This study involved mainly electron microscopy. Larger area morphology characteristics were investigated using x-ray diffraction techniques. This information was then used to support a theoretical model for possible packing of the rigid rodlike PBT molecules in the bulk fiber. Some mechanical properties were presented in correspondence with the fiber identification numbers of Celanese Research Corporation. This provided a conference-wide participation in the correlation of solution properties, processing parameters, and morphology/mechanical properties of PBT fibers.

3.4 UNIVERSITY OF DAYTON/UNIVERSITY OF DAYTON RESEARCH INSTITUTE
(Dr. A. V. Fratini and Dr. D. R. Wiff, Principal Investigators)

The molecular structures and packing diagrams of model compounds (both cis and trans configurations) of PBO and PBT were presented. This information was experimentally measured. It supplied accurate molecular parameters needed for theoretical predictions and for comparison with fiber x-ray diffraction pattern measured d-spacings.

Preliminary results of polefigure and orientation analysis on fibers and films via a fully automated x-ray diffractometer were presented. The rationale for performing a polefigure analysis was to allow an investigator to correlate the processing history and mechanical properties of a specimen with possible orientational changes of specific diffracting planes in the specimen.

3.5 SRI INTERNATIONAL
(Dr. J. Wolfe, Principal Investigator)

Following the previous discussions on the physical properties of the PBT polymer, the synthesis problems involved with scaling up the polymerization batch size were discussed. Possible future molecular engineering changes to enhance desired bulk polymer properties were discussed. Available quantities of PBT polymer for future studies by various contractors were presented to Dr. Helminiak, AFML/MBC.

3.6 POLYMER BRANCH, AFML
(Dr. R. Evers, Principal Investigator)

New synthesis routes to achieve a variety of new articulated or swivel copolymers were presented. These new macromolecular chains were specifically engineered to provide better bulk polymer properties, e.g., easier processing, higher modulus and tensile strength, etc.

3.7 UNIVERSITY OF CINCINNATI
(Dr. J. Mark, Principal Investigator)

Configurational statistical analysis was applied to various molecular configurations of the PBT molecule. In each case that configuration in correspondence with the minimum conformational energy was presented. The effect of the length of the articulated unit in the copolymer synthesis on the ease of the molecules to pack was important information required in guidance of synthesis efforts. A possible ideal packing scheme of the rigid rod molecules in the bulk polymer forms (fibers or films) was discussed.

3.8 STANFORD UNIVERSITY
(Dr. P. Flory, Principal Investigator)

An analysis of the effect of molecular weight and molecular weight distribution on the phase equilibria of rigid rodlike molecules in solution was presented from a theoretical viewpoint. Ramifications of these findings in light of the practical problems encountered in processing these materials were highlighted.

3.9 TEXAS A&M UNIVERSITY
(Dr. J. Holste, Principal Investigator)

The results were presented on the use of a unique solvent search technique. It appears that the only solvents for the polymers of interest are still highly protonating solvents, namely, strong acids.

3.10 COMPOSITES BRANCH, AFML/UNIVERSITY OF DAYTON RESEARCH
INSTITUTE
(Mr. G. Husman/Dr. D. R. Wiff, Principal Investigators)

Mechanical properties of various percent composition (rigid rod/flexible coil) blends were presented. A correlation between the mechanical properties, morphology (SEM photographs and x-ray diffraction crystallite size and orientation angles), and an extrapolation of chopped fiber composite theory toward the molecular level was discussed. Planned research to disperse the individual rigid rod molecules (i.e., eliminate any aggregation)

so as to increase the aspect ratio (of the chopped fiber) and, thus, greatly improve the mechanical properties completed the presentation.

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SECTION 5

CONCLUSION

The Ordered Polymers Research Program is directed toward the preparation and processing of very high strength, environmentally resistant polymers for use as structural materials in aerospace vehicles. In attendance were 95 scientists and technical managers from 36 different government, university and industrial research organizations. During the three days of review and discussion, presentations were made covering the research work being carried out at 11 laboratories within or under contract to the AFML or AFOSR. The basic theoretical work of Nobel Laureate Prof. P. Flory concerning phase equilibria of rigid rods in solution were considered in great detail.

The emphases of the program review were to determine the status of the various research efforts, improve and insure communications between the numerous investigators, inform the scientific community of the progress being made and plan and coordinate the research effort for the next six to 18-month increment.

The polymer PBT (poly-paraphenylene benzbisthiazole) was established as the material currently exhibiting the most favorable properties. Plans are completed to scale this material in pound quantities to further investigate processing. In fiber form, PBT has shown outstanding properties of 12.3 grams per denier tenacity and 1500 grams per denier modulus, as measured at room temperature. These values are especially encouraging because optimization of fiber formation has not been carried out.